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USSR Report

ENGINEERING AND EQUIPMENT

No. 88

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CONTENTS

UDC 621.039.514

USE OF BIFURCATION THEORY FOR ANALYSIS OF NUCLEAR REACTOR DYNAMICS

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 4, Apr 82
(manuscript received 20 Mar 81) pp 240-244

KOLTUNOVA, Ye. S.

[Abstract] The theory of bifurcation, namely dependence of the pattern of trajectory partition on the parameter, is applied to the analysis of dynamics in a nuclear reactor with delayed neutrons and two-temperature reactivity feedback. Of particular interest are slow processes, with the characteristic time of change in neutron density much longer than the characteristic time of change in concentration of delayed neutrons and the characteristic heating time. The system of four differential equations describing the dynamics is rewritten in vector form and solved by matrix calculus. The existence of a periodic solution, i. e., periodic oscillations about the steady state and the necessary change of parameters to obtain it are established. An analysis of bifurcation and its direction reveals that in this case, with delayed neutrons, this periodic solution is orbitally unstable and no self-excited oscillations occur. As to the boundary of stable steady reactor operation in the plane of reactor parameters, crossing this boundary into the region of instability should result in unlimited rise of reactor power. Figures 3, references 12: 11 Russian, 1 Western.
[244-2415]

UDC 534.9.019.3

DEFECTIVENESS OF TUNGSTEN IN HELIUM PLASMA OF GLOW DISCHARGE

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 4, Apr 82
(manuscript received 27 Apr 81) pp 253-256

SUVOROV, A. L., MEMELOVA, L. Ya., SAVVATIMOVA, I. B., BABAD-ZAKHRYAPIN, A. A., KUKAVADZE, G. M., BOBKOV, A. F. and ZAYTSEV, S. V.

[Abstract] An experimental study was made of treatment of VA-3 tungsten with helium plasma generated by glow discharge (150-500 V). The discharge

chamber had been filled with helium to $2.6 \cdot 10^3$-$3 \cdot 10^4$ Pa pressures, after evacuation to $6.6 \cdot 10^{-2}$ Pa, and the ion flux density then varied from $2 \cdot 10^{17}$ to $5 \cdot 10^{17}$ ions/($cm^2 \cdot s$) so as to build up a total dose of $2 \cdot 10^{21}$-$2 \cdot 10^{22}$ ions/cm^2. Acicular specimens of tungsten wire 0.1 mm in diameter and flat specimens of 50 μm thick tungsten foil were, after plasma treatment at 1000°C, examined under a field-emission microscope. This examination revealed the atomic structure of the tungsten surface and the evolution of defective regions, also the kinetics and the spectrum of helium release from treated specimens during their heating at a rate of 0.8°C/s above 1830 K (peaks occurring at 1600, 1620, 1690, 1715, 1730, 1760, 1800, 1830 K). According to these data, bombardment of tungsten with high-energy (500 eV) helium ions produces a crystal lattice of point defects and their complexes along with pores and depletion zones. Bombardment with low-energy helium ions (150-200 eV) does not produce such defects. The authors thank A. S. Alpeyev and A. A. Belonozhenko for direct participation in mass-spectrometric measurements, also Yu. G. Abov for his interest and support.
Figures 3, references 17: 12 Russian, 5 Western.
[244-2415]

UDC 621.039.519

MEASUREMENT OF REACTIVITY COEFFICIENT OF REACTORS IN BILIBINO ATETs

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 4, Apr 82
(manuscript received 8 Apr 81) pp 265-266

BONDARENKO, A. V., VAYMUGIN, A. A., DUSHIN, P. G., KOSTROMIN, A. G., MINASHIN, M. Ye. and SHARAPOV, V. N.

[Abstract] An outstanding feature of the Bilibino ATETs is operation of one or two power units according to a load curve with diurnal power variation. An experiment was performed for the purpose of determining the feasibility of automatic frequency control during periodic (every half hour) power reduction by 20-40% at a rate of approximately 0.5%/s, stabilization at the new level, and subsequent return to the original level. During this experiment the reactivity, flow rate, pressure and inlet temperature of the coolant were measured. These data were then used to determine the temperature coefficient of fuel reactivity, the power coefficient and the density coefficient of coolant reactivity, and the temperature coefficient of moderator reactivity. The last three coefficients can be represented as sums of two terms, one a constant and one proportional to the mean fuel depletion. Tables 2, references 2: 1 Russian, 1 Western.
[244-2415]

UDC 621.039.51.12

SOLUTION OF TRANSPORT EQUATION FOR RADIOACTIVE PARTICLES IN PRIMARY REACTOR LOOP

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 4, Apr 82
(manuscript received 20 May 81) pp 267-269

VASIL'YEVA, K. I., ZHILKIN, A. S. and KUZNETSOV, I. A.

[Abstract] The system of two partial differential equations describing the transport (concentration gradient and rate of change of concentration) of radioactive particles in a reactor loop is solved for initial and boundary conditions other than those corresponding to the basic case of a step perturbation of particle concentration at the entrance to an ideal loop. It is solved for the case of a long source of radioactive particles such as a fuel element or a contaminated pipe segment immersed in the coolant with an initially uniform surface concentration of particles. The mass transfer coefficients (precipitation and erosion) do not vary in time or in the direction of flow. The particle concentration in the coolant at the entrance to the tubular source is first assumed to be zero and then assumed to increase exponentially in time, as a result of radioactive fission. The solution of the equations involves a Laplace transformation and a subsequent inverse Laplace transformation. The solution can be put in the explicit form of an infinite series of modified Bessel functions and then evaluated for various ranges of parameter (distance from source) values. Figures 2, references 3 Russian.
[244-2415]

UDC 539.1/08:621.384.6

DESIGN OF NEUTRON TUBE WITH LASER SOURCE OF IONS

Moscow ATOMNAYA ENERGIYA in Russian Vol 52, No 4, Apr 82
(manuscript received 3 Jun 81) pp 271-272

GUL'KO, V. M. KOZLOVSKIY, K. I., KOLOMIYETS, N. F., LINEV, A. F., MINTS, A. Z., PLESHAKOVA, R. P., TOTSKIY, Yu. I. and SHIKANOV, A. Ye.

[Abstract] A neutron tube with a laser source of ions is described which can serve as a compact source of large neutron fluxes needed for generation of short high-intensity neutron pulses. The Q-switched laser beam is focused by a lens onto an ion generating target, where a substance containing deuterium or tritium is evaporated and ionized. The resulting plasma fills the tube, while pulses of an accelerating voltage are applied to the electrodes in the tube in synchronism with the laser flashes. Neutrons are generated at the target as a result of $D(d,n)^3He$ or $T(d,n)^2He$ reactions. The design of such a neutron source is consistent

with available technologies as well as with the physical laws governing the thickness profile of a layer of neutron generating substance deposited on the target surface by laser treatment. Experimental data confirm the theoretically predicted linear relation between number of neutron pulses and number of laser flashes. Figures 2, references 6 Russian. [244-2415]

BRIEF

JOINT MHD-GENERATOR RESEARCH WITH FINLAND--FNB--Various institutes and enterprises in Finland and the CEMA countries are starting cooperation on the matter of MHD power plants. On Friday [28 May] a cooperation protocol was signed by the Institute for Higher Temperatures of the Soviet Academy of Sciences [IVTAN] and the Tammerfors Technical University. They are both responsible for the coordination of the work. The cooperation concerns research on MHD-generators and development and production of parts for such power plants. The protocol was signed by A.E. Sheyndlin, member of the Academy of Sciences, and Osmo Hassi, vice-chancellor of the university. The program of cooperation was begun at the company level back in 1976. Nokia, Outokumpu, Strömberg, and Tampella participated in the project. At the signing of the protocol Academician Sheydlin emphasized the contribution of Finnish industry and said that he believed that other firms would also participate. The MHD-generator is an apparatus in which thermal energy is directly converted into electrical energy. In such power plants electrical and thermal energy are produced with smaller amounts of fuel than in ordinary power plants. The saving runs as high as 20 percent, and a saving of 40 percent and more is counted on in the future. In the research on this kind of technology the Soviet Union occupies the leading position. The agreement just signed does not open up any great commercial possibilities, but during the coming years the MHD technique and its applications may also be economically significant for Finnish industry, thanks to the big markets in the CEMA countries. [Text] [Helsinki HUFVUDSTADSBLADET in Swedish 29 May 82 p 18] 8815

CSO: 3109/175

UDC 621.51-33.001-5

COMPUTER-AIDED DESIGN OF HYDRAULIC VALVE WITHOUT MOVING PARTS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 82 pp 17-19

ANOKHIN, V. D., candidate of technical sciences, BELEN'KIY, A. A., candidate of technical sciences, BADAMYAN, A. A., engineer, and LEPEKHA, A. I., engineer

[Abstract] A new type of hydraulic valve has been developed which does not contain moving parts. It consists of an arcuate yoke on the inside and an arcuate deflector on the outside, both concentric and subtending the same central angle, with an array of curving blades on each. Operation of this valve is based on the appreciably different hydraulic drag in the forward direction and in the reverse direction of flow through the annular free channel between the two arrays of blades. Here the flow characteristics in each direction are analyzed on the basis of a simple model of steady flow of ideal incompressible fluid with almost uniform velocity and pressure profiles across the channel width, with necessary corrections for the effects of viscosity and compressibility. The relations between performance characteristics, particularly hydraulic losses, and geometrical characteristics yield the design parameters, i.e., the valve dimensions for optimum performance. Typical design calculations have been made on a digital computer and are shown here in the form of graphs. Figures 5, references 10 Russian.
[243-2415]

UDC 629.113:621.438-546.5.001.5

SOME RESULTS OF STUDIES OF AUTOMOBILE GAS-TURBINE ENGINE WITH REGULATION OF POWER TURBINE NOZZLE

Leningrad DVIGATELESTROYENIYE in Russian No 3, Mar 82
(manuscript received 23 Apr 81) pp 45-47

LUK'YANOV, V. I. and MAKHANEV, V. T., Gor'kiy Automobile Plane

[Abstract] A second-generation standard series of gas-turbine engines with regulation of the power turbine nozzle, including the 280 kW GAZ-902.10 and the 440 kW GAZ-903.10, is being developed for production at the Gor'kiy Automobile Plant. The double-housing construction of the nozzle regulation mechanisms with adjustable setting of the guide vane angle and with a tracking system for clearance stabilization ensures operation at sufficiently moderate and stable bearing temperatures. The most difficult problem in designing such a power turbine stage with nozzle regulation is reconciling the different aerodynamical and structural requirements, at times contradictory, for the various operating conditions. These include kinematic coupling of turbine and compressor rotors through an overdrive clutch for prolonged braking duty. The two major performance indicators affected by introduction of a nozzle regulation mechanism are reduced heat regeneration and lower efficiency of the power turbine. Thorough preliminary studies have been made at the Scientific Research Institute of Automobiles and Automobile Engines with single-row and double-row nozzle regulation mechanisms, for the purpose of evaluating all aerodynamic and other losses, as a basis for maximizing the overall efficiency with optimum fuel economy. It already appears feasible to reduce the fuel consumption to 0.235-0.240 kg/(kW.h) and to regulate these automobile gas-turbine engines for weather changes from -30 to +30°C, by varying the guide vane angle from 22-25° to 14-16°, which will require optimization of the profile of the power turbine stage. Figures 3, references 6: 5 Russian, 1 Western.
[246-2415]

UDC 621.165.6

EFFECT OF RIBBING ON STRUCTURAL RIGIDITY OF OUTER SHELL OF LOW-PRESSURE TURBINE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 82 pp 20-21

BYCHKOV, A. N., engineer, KOMALETDINOV, M. S., engineer, and YUZHAKOV, L. I., engineer

[Abstract] The feasibility of constructing a light-weight but rigid outer shell for low-pressure turbines was studied on a model of such a turbine housing made of acrylic plastic. The structure included flanges as well as an array of reinforcing hoops and stringers. The load-deformation characteristics and the states of stress and strain under varying gage pressures and vacuum inside were measured with strain gages and transducers during simulation tests, every 3 min during a loading cycle (each test cycle repeated three times) and every 10 min after load removal. An evaluation of the data on the basis of energy relations and the equation of flexure for a frame with ribbing under load reveals that the load acting on the upper half of the housing is carried by the hoops. Consequently, the hoops are stressed more than other elements of the structure and their stiffness determines its rigidity. Welded-in flanges increase the circumferential rigidity of such a shell. Figures 4, references 3 Russian. [243-2415]

UDC (621.515+621.67)001.24

EXPERIMENTAL STUDY OF VIBRATIONS CAUSED BY TURBINE SHAFT SEALS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 82 pp 5-8

BONDARENKO, G. A., candidate of technical sciences, and PSHIK, V. R., engineer

[Abstract] An experimental study was made of self-excited turbine runner vibrations atrributable to the presence of contactless shaft seals. A turbine runner mounted on stiff ball bearings with pairs of identical seals, to eliminate axial forces, was tested in a special high-speed stand with independent bearing and seal supports. In each test the oil pressure in the seals was maintained constant and the runner speed was varied from 0 to 2000 rad/s (70 m/s at shaft journal). The critical speeds were found in three ways: upon impact excitation of the shaft, by running the shaft "bare" without seals, and on the basis of calculations. Buildup of self-excited vibrations was indicated by an increase of the sound level with a characteristic tone, some heating, and some drop of pressure. The test data have been evaluated by conversion of oscillograms to amplitude-frequency curves. The results reveal that of the four types of seals tested,

labyrinth seals are most culpable as cause of vibrations and honeycomb seals cause hardly any vibrations at all. With clearance seals self-excited vibrations occur at speeds above double or triple the critical, depending on damping and seal pressure when both drop below some threshold. With helical seals self-excited vibrations occur always at double the critical speed, with attendant precession at a frequency close to the natural. The self-excited vibrations were generally found to be stable and controllable by seal design. Figures 7, references 4 Russian.
[243-2415]

UDC 536.24:532.526

MORE EFFICIENT COOLING OF FLUE IN GAS-TURBINE COMBUSTION CHAMBERS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 82 pp 2-5

KHRISTICH, V. A., doctor of technical sciences, and SHEVCHENKO, A. M., candidate of technical sciences

[Abstract] As modern gas turbines are designed for higher compression ratios and higher gas inlet temperatures, it becomes necessary to more efficiently cool the flue in the combustion chamber with less available air (more air required for burning the fuel). It has been recommended that the flue walls be cooled by impact of air jets. Here the merits of this method are demonstrated on the basis of thermodynamic and flow analysis. Relations are established which characterize interaction and heat transfer during impact of air jets against a wall, in this case a mesh screen. A perforated flue pipe has been designed to optimize the heat transfer and to avoid drift of the air stream from its path of maximum effectiveness. The concept has been incorporated and tested in several gas turbine plants: a flue consisting of 12 perforated duct segments in the heavy-duty PGU-120 and PGU-200-750 units at the Nevinomyssk GRES and the Leningrad GES respectively, and a double-wall flue consisting of solid annular shells with corrugated inside surface in GT-25-700 and GTN-9-750 units manufactured at the Leningrad Metal Plant. Figures 5, table 1, references 11: 10 Russian, 1 Western.
[243-2415]

NAVIGATION AND GUIDANCE SYSTEMS

UDC 534.1

STABILITY AND SELF-EXCITED VIBRATIONS OF COAXIAL ROTORS

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEHANIKA TVERDOGO TELA in Russian
No 2, Mar-Apr 82 (manuscript received 4 Mar 80) pp 38-45

POZNYAK, E. L., Moscow

[Abstract] Self-excited vibrations during flight of two rotors on coaxial shafts inside a rigid housing on dampers are analyzed, assuming that external friction with a viscous component and internal friction in the shaft material are the only nonconservative forces in the system. The equations of motion for all three components are solved for determination of the stability range. This range is found to narrow down when both rotors spin simultaneously in the same direction and to widen when they spin simultaneously in opposite directions. Calculations reveal that steady solutions to the system of equations do not always exist, despite the presence of nonlinear damping, unless there is a nonlinearity in each of the three equations. The form of the solution corresponds to the number of vibration (self-excited) modes and frequencies, which in turn depend on the initial conditions. Figures 5, references 9: 8 Russian, 1 Western. [242-2415]

UDC 531.55

MAXIMIZING FLIGHT RANGE OF AIRCRAFT

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 2, Mar-Apr 82 (manuscript received 22 Dec 80) pp 20-24

BORZOV, V. I. and IGONINA, T. R., Moscow

[Abstract] The motion of an aircraft is analyzed, disregarding both curvature and rotation of the earth. The problem is to maximize the flight range in a certain time with a given engine thrust. The motion of the center of mass is controlled by varying the aircraft orientation relative to the velocity vector and thus adjusting the aerodynamic coefficients

(lift and drag). The optimum control is found according to Pontryagin's principle of the maximum. The problem reduces to a system of differential equations with singular perturbations and solvable, for given boundary conditions, by the method of asymptotic expansions. References 5: 4 Russian, 1 Western.
[242-2415]

UDC 531.383

SOME PROPERTIES OF GYRO SYSTEMS ASSOCIATED WITH HERTZ CONCEPT IN MECHANICS

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 82 (manuscript received 13 Jan 81) pp 15-19

ZHURAVLEV, V. F., Moscow

[Abstract] In an application of the Hertz concept, a mechanical system with n positional and m cyclic coordinates is sought which, with the cyclic coordinates ignored, would be equivalent to a closed autonomous energy-conservative zero-force mechanical system. Two theorems are stated and proved regarding the potentiality criterion for Lorentz gyroscopic forces. On this basis, corrolaries are established for the necessary and sufficient conditions of existence of such a gyroscopic system. References 6: 4 Russian, 2 Western.
[242-2415]

UDC 531.383

DYNAMICS OF ELECTROSTATIC GYROSCOPE WITH PULSE-TYPE REGULATION SYSTEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 82 (manuscript received 21 Apr 80) pp 6-14

GUBARENKO, S. I. and MARTYNENKO, Yu. G., Moscow

[Abstract] An unbalanced electrostatic gyroscope with a spherical wheel inside a spherical vacuum cavity is considered and the motion of this wheel in a uniform gravitational field is analyzed, assuming the central ellipsoid of inertia to be an ellipsoid of revolution. The wheel is perfectly solid and the housing is stationary, the electrode potentials are regulated by a special system which tracks the wheel displacements in discrete instants of time. The corresponding nonlinear differential equations are solved asymptotically, after separation of fast variables (precession angle, intrinsic spin angle, displacement of geometric center) from slow variables (acceleration of gravity, nutation angle, angles of two successive rotations about axes of an orthogonal reference trihedron). The general

results of this analysis are applied specifically to pulse control of a gyroscope wheel with respect to two coordinates of its geometric center. The authors thank I. V. Novozhilov for discussing the article. Figures 3, references 6: 5 Russian, 1 Western.
[242-2415]

UDC 621.373.826.038.824

MODEL LZhI-502 TUNABLE DYE LASER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 82 (manuscript received 25 Jun 80) pp 225-226

ZHIL'TSOV, V. I., KONSTANTINOV, B. A., KOZLOV, N. A., MNUSKIN, V. Ye., SAMONOV, S. F. and FEDOROV, V. A.

[Abstract] The model LZhl-502 dye laser is intended for spectroscopy of high-speed processes, plasma diagnosis, supersensitive analysis of micro-impurities, isotope separation, etc. It consists of a vessel in which the active solution is pumped through the excitation space, an optical cavity formed by an opaque mirror and an exit mirror, a dispersing module and a focusing lens. The dispersing module includes a set of three quartz prisms and a set of two glass prisms, each interchangeable for operation in three spectral ranges: 360-420 nm, 420-500 nm, 470-850 nm. The cell for the active medium is made of metal with quartz windows. Several interchangeable cells with active media are available for covering the entire 360-850 nm spectrum. An emission line of 0.1 nm width is obtained with the aid of a Fabry-Perot etalon. Pumping requires a pulse laser producing a beam with diameter smaller than 7 mm and divergence smaller than 3 mrad, peak power higher than 40 kW. With a "Kabal'yero-1" 40 kW nitrogen laser used for pumping, the LZhl-502 laser produces a beam of 6 kW peak power in emission pulses for 10 ns duration at repetition rates up to 500 Hz. The beam diameter is 1.0 mm, its average power at medium pumping power is 15-100 mW. Figure 1.
[241-2415]

UDC 621.378.3

MERCURY-VAPOR PULSE LASER WITH EMITTED BEAM OF LARGE DIAMETER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 82 (manuscript received 23 Dec 80) p 225

ZINCHENKO, S. P., IVANOV, I. G. and SEM, M. F.

[Abstract] A gas laser is available for pulse emission of coherent radiation, red (615.0 nm) with a 3000 MHz wide line and near infrared (794.5 nm) with a 600 MHz wide line. The active medium is a mixture of mercury vapor (0.3 torr) and helium (8 torr), excited in a gas pulse discharger with a hollow cylindrical cathode. The diameter of the emitted beam can be made as large as 30 mm. The pulse power is 10 W and the average power is 5-50 W at the 615.0 nm wavelength with pulse repetition rate of 0.5-5 kHz. The device operates with natural air cooling. It weighs 3.5 kg. Figure 1. [241-2415]

UDC 621.378.325

MULTIFREQUENCY SOURCE OF LASER RADIATION

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian, No 2, Mar-Apr 82 (manuscript received 17 Jul 80) pp 168-169

AKMANOV, A. G. and VAL'SHIN, A. M., Bashkir State University, Ufa

[Abstract] A laser source with a garnet crystal as active medium and a prismatic dispersing resonator has been built for tunable emission at the λ = 1.064 μm transition as well as at the $4F/_{3/2} \rightarrow 4I_{13/2}$ transition (λ = 1.3188, 1.3382, 1.3566 μm). This is made possible by proper matching of the reflection coefficients of the two plane-parallel resonator mirrors. An $LiNbO_3$ nonlinear crystal serves as electrooptic shutter for cavity Q-switching. The latter includes also a set of three 60° prisms made of TF-3 glass. The active element, a 5x65 mm garnet crystal, is pumped from an IFP-800 flash lamp inside a quartz reflector. This device was used successfully for pumping cascade generators of optical harmonics through frequency conversion. A typical fifth-harmonic generator consists of an $LiNbO_3$-crystal frequency doubler stage passing all laser frequencies, followed by a KDP-crystal frequency doubler stage and a KDP-crystal frequency mixer (fundamental and fourth harmonic) with a filter, and an output prism. Figure 1, tables 2, references 4: 3 Russian, 1 Western [241-2415]

UDC 621.387.322.4:621.316.933

HIGH-VOLTAGE LASER-TYPE SPARK DISCHARGER

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 82 (manuscript received 7 Jan 81) pp 142-144

MYSHALOV, P. I., BUSHUK, B. A., TIKHOMIROV, S. A. and TOLSTOROZHEV, G. B., Institute of Physics, BSSR Academy of Sciences, Minsk

[Abstract] A spark discharger has been built for use in a Pockels cell for extraction of single ult short pulses from pulse trains. It consists of a sealed chamber contain ig an inert gas under a gauge pressure of approximately 1.5 MPa and two electrodes in the form of spherical caps (radius 30 mm) made of 12Kh18N10T stainless steel to which a high voltage of 30 kV is applied through hermetic plugs. The laser beam enters through a window in the chamber behind the anode and then passes through an axial hole in the latter. The cathode can be moved by a micrometer screw along its and the anode's common axis, for regulation of the interelectrode gap from 0 to 15 mm. The device was tested in a Pockels cell with a Glan prism and a DKDP crystal, and found to be capable of extracting a 5 ns light pulse with 1 ns rise time. Figures 3, references 2 Russian.
[241-2415]

UDC 621.384.6

DEVICE FOR LOCATING CHARGED-PARTICLE BEAM

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 82 (manuscript received 28 Jan 80) pp 139-142

BOLOTIN, I. M., BYSTROV, Yu. A., ZAGRANICHNYY, Ye. N., MAMAYEV, G. L., RADCHENKO, Yu. F. and SHCHERBAKOV, A. M., Leningrad Institute of Electrical Engineering

[Abstract] An electronic device for locating a charged-particle beam has been developed on the basis of interaction of such a beam with a magnetic field in vacuum. The transducer part consists of two pairs of electrode sets placed symmetrically with respect to the geometric center of the device, i.e., on opposite sides of it. Each set consists of a heated flat cathode between two cross-connected anodes. The ratio of anode currents depends on the intensity of the magnetic field produced by the beam current. Without an electron beam there is no signal voltage. With an electron beam off center there is also no output signal, but with the electron beam off center there appears an unbalance voltage at the transducer output which is a function of both beam current and beam displacement $V_{out} = f(i,x,y,)$. The actual output characteristic compares with the theoretical one based on the equation of motion for electrons in a magnetically sensitive diode, if changes occurring in the magnetic induction are taken into account. They

are both nonlinear, but can be linearized within the initial range. To the small error of such an approximation must be added errors due to transverse and normal drift of electrons away from the beam axis. The device includes a log-antilog divider for normalization of its analog signal over the 0-1 MHz frequency range. The device can locate the center of charged-particle beams with currents up to 1500 A within a 40 mm measurement range, with adjusted error not exceeding $\pm$10% and a sensitivity of 0.4 V/(mm.kA). Figures 4, references 7 Russian.
[241-2415]

UDC 621.384.6

ELECTRON GUN FOR FORMING TWO HIGH-CURRENT BEAMS

Moscow PRIBORY I TEKHNIKA EKSPERIMENTA in Russian No 2, Mar-Apr 82 (manuscript received 4 Mar 81) pp 19-21

BORISOV, A. R., ZHERLITSYN, A. G., MEL'NIKOV, G. V. and SHTEYN, Yu. G., Scientific Research Institute of Nuclear Physics, Tomsk Polytechnic Institute

[Abstract] The electron gun for a "Tonus" accelerator has been redesigned so that formation of two synchronized high-current beams is now possible. Its main feature is two cathode holders joined to the high-voltage pulse receiving electrode through split connecters at right angles to each other. The cathode holders are thin-walled tubular segments made of stainless steel. Either of them can be disconnected for conventional single-beam operation of the gun. The electron beams are generated either by flat diodes or by coaxial diodes with magnetic insulation. The performance of both variants was measured with a forming voltage of 0.9-0.95 MV. The results indicate changes in the distribution of currents between diodes as well as in the magnitudes of current and accelerating voltage, as the interelectrode gap in one diode is varied in the first case and as the intensity of the insulating magnetic field is varied in the second case.
The authors thank A. N. Didenko, G. P. Fomenko and Yu. G. Yushkov for their steady interest in this study. Figures 3, references 3: 1 Russian, 2 Western.
[241-2415]

UDC 532.517.2

KINEMATIC SINGULARITIES IN FLOW AT SURFACE OF SEGMENTALLY CONICAL BODIES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 2, Mar-Apr 82 (manuscript received 27 Jun 80) pp 143-146

ANDREYEV, G. N., GLAGOLEV, A. I., ZUBKOV, A. I. and LYAGUSHIN, B. Ye.,
Moscow

[Abstract] Hypersonic separation flow at segmentally conical blunt bodies was studied in a wind tunnel, with the oncoming stream having a Mach number $M = 6$ and a Reynolds number $Re = 5.9 \cdot 10^6$ referred to the maximum tunnel diameter, with a stagnation temperature $T_s = 480$-500 K and with the angle of attack varied from 5 to 90°. The model consisted of a spherical segment (central angle 60°) and a right cone (vertex angle 20°) with a common base 55 mm in diameter. The experimental data serve as basis for analysis of the flow pattern, namely changes in the limiting lines and in the number of singular points, as the angle of attack increases. There are always two more foci or nodes than saddle points, maximum six and four respectively at angles of attack approaching 55°. Figures 5, references 4: 3 Russian, 1 Western.
[238-2415]

UDC 532.5.013.4:538.4

STABILITY OF CIRCULAR CYLINDRICAL CONFIGURATION OF LIQUID METAL MAINTAINED BY HIGH-FREQUENCY FIELD

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 2, Mar-Apr 82 (manuscript received 21 Jun 80) pp 139-142

LADIKOV-ROYEV, P. Yu., Kiev

[Abstract] A high-frequency electromagnetic field induced by surface currents in a cylindrical inductor filled with metal melts the metal and causes it to separate from the inside wall of the inductor. This process is analyzed here, assuming that the frequency of the field is very high and,

therefore, its depth of penetration negligibly small. Accordingly the field acts only in the vacuum gap between metal and inductor. The equation of equilibrium of forces, including gravity and surface tension as well as the force of the magnetic field, is formulated in cylindrical coordinates. The stability of this equilibrium is examined by the method of small perturbations, with averaging over a period of the high-frequency field, which yields an infinite equation for the eigenvalues. The results of calculations and analysis reveal that the metal cannot be maintained in its configuration without a longitudinal field component, and that a longitudinal field component without a phase shift will also not stabilize the metal. Table 1, references 2 Russian.
[238-2415]

UDC 533.6.011.72

TRANSITION FROM MACH TO REGULAR DURING INTERACTION OF STRONG SHOCK WAVES AND CYLINDRICAL SURFACES

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 2, Mar-Apr 82 (manuscript received 23 Jan 80) pp 132-138

GVOZDEVA, L. G., LAGUTOV, Yu. P. and FOKEYEV, V. P., Moscow

[Abstract] Reflection of a shock wave by convex and concave cylindrical surfaces is considered, a transition from Mach to regular reflection or vice versa occurring at some critical incidence angle. An experimental study was made to determine the dependence of this critical angle on the intensity of the primary wave as well as on the preceding interaction of wave and surface. Tests were performed with concave surfaces ($\alpha°$, r mm) = = (0,72), (6,100), (28,100) and a convex surface ($\alpha = 71°$, r = 123 mm) (α- angle between plane intersecting the cylinder parallel to its axis and plane tangent to the cylinder at the line of intersection, r- radius of cylinder) in air and in nitrogen inside a shock tube of square cross section (72x72 mm). Measurements were made by the shadow method and holographic interferometry with a spark discharge or an OGM-20 laser. The results indicate that Mach reflection of shock waves by concave surfaces extends down to incidence angles smaller than those for a plane surface and at surfaces with $\alpha = 0$-$6°$ even smaller than corresponding to a "stationary" Mach cone. The critical angle does not depend on the radius of the cylindrical surface. Figures 5, references 11: 3 Russian, 8 Western.
[238-2415]

UDC 532.529:533.6.011

EFFECT OF VISCOUS BOUNDARY LAYER ON SEDIMENTATION OF PARTICLES IN GASEOUS SUSPENSION FLOWING AROUND SPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 1, Jan-Feb 82 (manuscript received 2 Jun 80) pp 59-66

TSIRKUNOV, Yu. M., Leningrad

[Abstract] Flow of a viscous homogeneous two-phase (gas-solid) stream around a spherical body is analyzed, assuming the gas to be incompressible and the concentration of suspended spherical particles to be so low as not to affect the flow. The corresponding equations of motion are solved, assuming the velocities of gas and particles to be equal in the unperturbed region. The solution, obtained by numerical integration with the Reynolds number varied from 10^3 to 10^7, reveals the pattern of sedimentation on the surface and the effect of the boundary layer. Here particles near the surface can lose their normal velocity component and remain "in suspension", slowly drifting along the body with the friction force always much larger than the buoyancy force and the apparent body force. The author thanks Yu. P. Savel'yev for helpful discussion. Figures 5, references 12: 9 Russian, 3 Western.
[248-2415]

UDC 532.526.75:518.61

LAMINAR FLOW OF VISCOUS FLUID BETWEEN ROTATING DISKS

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 1, Jan-Feb 82 (manuscript received 6 Jun 80) pp 76-81

MATVEYEV, Yu. Ya. and PUSTOVALOV, V. N., Khar'kov

[Abstract] The problem of steady axisymmetric flow and heat transfer, assuming negligible viscous friction, is solved for a viscous incompressible fluid between two rotating disks. The corresponding complete Navier-Stokes equations in dimensionless form are reduced to a system of four differential equations of identical structure but different parameters in their coefficients. These equations have been solved by the explicit conservative scheme, assuming uniform temperature and pressure profiles at the inlet, with directional differences in divergence form approximating the convection terms. Numerical data have been obtained with the aid of a BESM-6 computer for four sets of values of Reynolds number, initial twist, and kinematic coefficient. The results are applicable to problems of cooling a turbine stage. The authors thank V. M. Kapinos for discussion and helpful comments. Figures 4, references 15: 8 Russian, 7 Western.
[248-2415]

UDC 533.6.011

SYMPTOTIC SOLUTION TO PROBLEM OF HYPERSONIC FLOW AROUND BODIES NEAR SEPARATION POINT OF THIN SHOCK LAYER

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 1, Jan-Feb 82 (manuscript received 12 May 80) pp 99-105

ABRAMOVSKIY, Ye. R. and LYCHAGIN, N. N., Dnepropetrovsk

[Abstract] Transition from attached to separated boundary layer due to a shock wave during hypersonic flow of gas around a symmetric convex body with continuously varying surface curvature is analyzed on the basis of an asymptotic solution to the equations of motion and continuity. The singularity of the solution is removed by expressing the principal pressure component as a subcritical shock wave so that it will nowhere vanish within the shock layer. As special cases are considered acute and obtuse nose cones, with a negligible effect of the entropic boundary layer in the latter case. The pressure is calculated according to the Newton-Buseman relation. Numerical data have been obtained for a circular cone with a 20° vertex angle and a 30° angle of attack. The agreement between asymptotic solution and numerical solution improves as the adiabatic exponent γ is reduced from 1.4 toward 1. Figures 3, table 1, references 16: 13 Russian, 2 Western.
[248-2415]

UDC 533.6.07

GAS DENSITY DISTRIBUTION IN VORTEX FILAMENT NEAR MODEL OF DELTA WING AT NONZERO ANGLE OF ATTACK AND VELOCITY $M_\infty = 2$

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 1, Jan-Feb 82 (manuscript received 25 Mar 80) pp 119-125

ALFEROV, V. I., VERNIKOVA, N. G. and PODMAZOV, A. V., Moscow

[Abstract] An experimental determination was made of the density field in the core of a vortex filament behind a 0.1 m long model of a symmetric delta wing with an 85° sweepback angle at a 15° angle of attack in a nitrogen stream with the Mach number $M_\infty = 2$ and the Reynolds number $Re = 0.9 \cdot 10^6$. Tests were performed in a closed wind tunnel, measurements were made with a Pitot tube, spectrographs and photomicrographs were obtained in the light of a glow discharge. This method is based on the theory of optical radiation from an electric glow discharge and the dependence of the radiation intensity on the gas density along the light path. Figures 5, references 20: 13 Russian, 7 Western.
[248-2415]

UDC 533.607.14:534.29

SUPPRESSION OF SELF-EXCITED VIBRATIONS IN CLOSED WIND TUNNELS WITH OPEN TEST ZONE

Moscow IZVESTIYA AKADEMII NUAK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 1, Jan-Feb 82 (manuscript received 10 Jul 80) pp 126-132

BOYARCHIKOVA, M. Yu., VLASOV, Ye. V., GINEVSKIY, A. S. and ZOSIMOV, A. V., Moscow

[Abstract] Interaction of periodic fluctuations in the free gas jet and acoustic vibrations (standing waves) in the return channel of a closed wind tunnel with open test zone produces self-excited vibrations within certain velocity ranges. An acoustic method of suppressing these vibrations has been developed which utilizes the attenuating effect of high-frequency acoustic irradiation on the turbulence in a subsonic jet. The method was tried experimentally in two wind tunnels: one with a nozzle 0.15 m in diameter, a 0.3 m long open test zone and a 7.8 m long return channel; one with a nozzle 0.44 m in diameter, a 1 m long open test zone and a 21 m long return channel. Tests were performed at velocities of 10-45 m/s and 10-50 m/s respectively, with the Reynolds number $Re = (1-4)\cdot10^5$ and $Re = (0.3-1.5)\cdot10^6$ respectively. Velocity fluctuations were measured with a constant-temperature hot-wire anemometer in the $(0-5)\cdot10^3$ Hz frequency range. Pressure fluctuations were measured with a condenser microphone under a shield for protection against wind. Signals from these transducers were recorded on an oscillograph for subsequent processing in terms of dimensionless fluctuation and vibration spectrum parameters. Acoustic irradiation was found to either produce self-excited vibrations or amplify existing ones in the 0.1-1.4 range of the Struhal number and to attenuate existing self-excited vibrations in the 2-5 range of the Struhal number. Optimally matched acoustic radiation should suppress self-excited vibrations without perceptibly altering the average-velocity profile in the open test zone. Figures 4, references 4 Russian.
[248-2415]

UDC 536.6.011

HYPERSONIC FLOW AROUND RECTANGULAR BASE OF PRISM DURING INTENSE GAS INJECTION THROUGH BASE SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA in Russian No 1, Jan-Feb 82 (manuscript received 16 Jun 80) pp 154-166

VIGDOROVICH, I. I., Moscow

[Abstract] Hypersonic flow around the base of a rectangular prism or of a circular cylinder during intense gas injection through the surface is analyzed, in dimensionless Cartesian or cylindrical coordinates respectively, assuming a Newtonian pressure distribution $p = p_0\cos^2\theta$ (p_0 - stagnation

pressure behind forward pressure jump, θ - slant angle of contact surface). The boundary-value problem for the Mises equations describing the motion of gas in the "thin" injection layer is reduced to an integral equation. Solutions are obtained in the form of asymptotic expansions, the external solution for region 1 (in stream with plane or axisymmetric flow) and the internal solution for region 2 (at surface with plane flow). An analysis of the total solution reveals that there is an optimum injection rate corresponding to minimum drag at the surface. The author thanks V. A. Levin for the interest shown and helpful discussions. Figures 6, references 24 Russian.
[248-2415]

UDC 532.516.5:518.9

ROTATING CYLINDER IN STREAM OF VISCOUS INCOMPRESSIBLE FLUID

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA ZHIDKOSTI I GAZA
in Russian No 1, Jan-Feb 82 (manuscript received 26 Jun 80) pp 16-21

SHKADOVA, V. P., Moscow

[Abstract] A solution to the Navier-Stokes equations in polar coordinates is sought for a cylinder rotating at constant angular velocity in a stream of viscous incompressible fluid, with appropriate boundary conditions for the flow function and the vorticity. Results are obtained by numerical integration for relative velocity of the cylinder from 0 to 3 at a Reynolds number Re = 40, for values of the Reynolds number Re from 10 to 80 at a relative velocity of the cylinder $\varepsilon = 0.2$, and for a stationary cylinder in a stream with the Reynolds number varied from $Re < 40$ to $Re > 60$. The author thanks G. I. Petrov and V. Ya. Shkadov for helpful discussions. Figures 3; references 6: 5 Russian, 1 Western.
[248-2415]

UDC 533.6.013.42

ACTION OF WEAK SHOCK WAVES ON ELASTIC SPHERICAL SHELL

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 82 (manuscript received 3 Mar 80) pp 176-182

ALEKSANDROVA, N. A., Leningrad

[Abstract] A spherical shell containing a compressible fluid at zero pressure is placed concentrically inside an elastic larger one. The inner shell explodes suddenly, which gives rise to spherical pressure waves propagating toward the outer shell. The inner shell, after fracture, is assumed to have no further influence on the motion of the fluid. In the case of weak pressure waves and a thin outer shell one can describe the motion of the fluid by equations of acoustics and the vibration of the outer shell by the equation for thin shells. Calculating the deformation of the outer shell involves solving the wave equation for the case of spherical symmetry and boundary conditions corresponding to nonseparation flow. A solution is obtained with the aid of Laplace transformation. It is demonstrated that inverse transforms of pressure $p_0(t)$ and deflection $w_0(t)$ at the shell surface exist, depending uniformly continuously on the parameters m,k in the relation $w_0(s) = \frac{p_0(s)}{ms^2+k}$ at any time on the [0,T] interval. They are evaluated, beginning with the case of a perfectly rigid shell as the first approximation. Here dynamic effects of sudden load dumping can raise the pressure on the wall and increase the deflection of the wall appreciably above the initial static ones. This is also found to be possible, under certain conditions, in the case of an elastic shell. Figures 3, references 3 Russian.
[249-2415]

UDC 539.3

LOAD TRANSFER FROM ELASTIC RIB TO SEMI-INFINITE ANISOTROPIC SHELL

Moscow IZVESTIYA AKADEMII NUAK USSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 82 (manuscript received 4 Sep 79) pp 150-158

FIL'SHTINSKIY, L. A., Sumy

[Abstract] The T-periodic fundamental solution to the equations of the theory of anisotropic shallow shells is applied to a shell of semi-infinite length with an elastic stiffening rib and various constraints at the end. The problem of load transfer from rib to shell is solved by means of the Green function for such a structure, representable as the solution to the corresponding nonhomogeneous resolvent equation and usually expressible as a sum of exponential functions of its complex variables. For application to this contact problem, the Green function is transformed through successive extractions of the "principal part" of regular components. The procedure is demonstrated on the specific case of a shell with stiffening stringers under tension, equal axial forces assumed to act on the stringers only. A special case of interest is that of overhanging stringers. The condition of compatibility with respect to strains yields a singular integro-differential equation containing the Green function of time and space coordinates G(t,x), which has been solved numerically for specific values of shell and stringer parameters (materials: Textolite, AG-4S fiber glass, plywood). The author thanks V. A. Lyubchak for assisting in the numerical implementation of the algorithms and discussing the results. Figures 5, references 10 Russian.
[249-2415]

UDC 531.8

PARAMETRIC OPTIMIZATION OF MOTION OF BIPED WALKING MECHANISM

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 1, Jan-Feb 82 (manuscript received 5 Jun 79) pp 28-40

BELETSKIY, V. V., BERBYUK, V. Ye. and SAMSONOV, V. A., Moscow and Kishinev

[Abstract] Earlier studies of biped walking are continued here by consideration of a plane nonlinear mechanism with actively controllable feet. The mechanism model is one of an inert ponderable body on two identical legs, each of the latter consisting of three links: thigh and shank (both inert and ponderable) and foot (inertialess and weightless extremity). The step motion of such a mechanism is described by Lagrange equations of the second kind in generalized coordinates, to which are added two kinematic constraints on horizontal and vertical displacements respectively. Single-support motion, with only one foot on the ground at any instant of time,

is analyzed as for a system with nine degrees of freedom. The corresponding nine time functions are stipulated to satisfy the requirements of rhythmical and continuous motion, conformance to natural anthropomorphic laws of movement, smooth pace, no sliding on ground, zero foot velocity at instants of touch down and take off, and a specific height to which foot will rise. The problem has not just one unique solution and, for the purpose of optimization of the walking mode, can be formulated in two ways: with given length of step and maximum height of foot above ground, 1) find the energy-optimal walking mode in the set of those with comfortable pace and body movement; 2) find the energy-minimal walking mode in the set of those with uncomfortable pace and body movement. Both have been solved numerically for specific values of the constraining parameters. A comparative analysis of the results indicates that the walking mechanism with controllable feet designed to walk in uncomfortable kinematic mode will be the one kinematically most appropriate. Figures 14, references 14: 10 Russian, 4 Western. [249-2415]

UDC 539.3

DIFFRACTION OF LONGITUDINAL WAVE BY ROW OF HOLLOW CIRCULAR INCLUSIONS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 13 Oct 80) pp 120-123

CHEREVKO, M. A., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] An unbounded elastic body is considered which contains a periodic row of k identical deformable inclusions in the form of hollow circular cylinders. Each inclusion is referred to its own cylindrical system of coordinates with the origin at the center and with the z-axes of all parallel. A plane longitudinal wave with its front parallel to the z-axes propagates through this body at some angle to the center line of the inclusions. The resulting state of stress and strain is obtained from the solution to the wave-potential equations $\Delta\phi_j^{(k)} + \alpha_j^2\phi_j^{(k)} = 0$ $(j = 1,2)$ for the body and equations $\Delta\phi_j^{*(k)} - \alpha_j^{*2}\phi^{*(k)} = 0$ for the inclusions. The solution reduces to an infinite system of linear algebraic equations solvable, in asymptotic representations, by the reduction method. For illstruation, the procedure has been applied to the problem of diffraction of a longitudinal wave incident normally to the center line of the inclusions. Figures 5, references 4: 3 Russian, 1 Western. [247-2415]

UDC 539.4

PROPAGATION OF WAVES THROUGH STRUCTURE FORMED BY MULTILAYER MULTICOMPONENT COMPOSITE MATERIAL

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 7 Apr 80) pp 117-120

SHUL'GA, N. A., Institute of Mechanics, UkSSR Academy of Sciences, Kiev, and ANTONENKO, V. M., Kiev Institute of Automobile Roads

[Abstract] A composite material si considered consisting of identical layers of a maeerial which, in turn, consists of $Q \geq 2$ isotropic components with different thicknesses, densities, and elastic properties. Propagation of longitudinal and transverse waves through such a structure occupying a quarter-space is analyzed on the basis of solutions to the wave equation for each component in each layer. The conditions of continuity with respect to displacements and stresses yield an infinite homogeneous system of algebraic equations which can be reduced to the homogeneous equation

$(M_Q - \frac{E_2}{\varkappa})\vec{X} = 0$ (M_Q - transmission matrix for Q components, E_2 - unit matrix, $\varkappa$ - scalar, $\vec{X} = (X_1, X_2)^T$ - two-dimensional vector-column). The quadratic characteristic equation $\varkappa^2 - 2b\varkappa + 1 = 0$ (b = spur M_Q) yields undamped waves as well as waves bounded at infinity when both its roots are equal to unity in absolute value, which is possible when $|b| \leq 1$. It also yields the dispersion relation $\cos\varphi = b$ ($|b| \leq 1$, φ- parameter corresponding to dimensionless wave number). Numerical results have been obtained for two-component materials with the ratio of densities $\rho_1/\rho_2 = 2$, the ratio of Young moduli varying over the $20 \leq E_1/E_2 \leq 80$ range, and the relative thickness of the first component varying over the $0.3 \leq \beta_1 \leq 0.7$ range, also for multicomponent ($Q = 3,4$) materials. Figures 4, references 8: 7 Russian, 1 Western.
[247-2415]

UDC 539.3

DESIGN OF VARIABLE-STIFFNESS SANDWICH SHELLS WITH COMPRESSIBLE FILLER

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 2 Jun 80) pp 54-59

PUKHLIY, V. A., Central Scientific Research and Experimental Design Institute of Industrial Buildings and Structures, USSR Central State Construction Office, Moscow

[Abstract] The equations of equilibrium for a shallow variable-stiffness sandwich shell with a rigid compressible filler are derived from the strain-displacement relations and the appropriate Lagrange variational equation.

These equations, generally intricate, simplify for the special case of a light-weight filler. Here they are solved for the design of a trapezoidal blade of a radial compressor with two uniform-thickness curving sheaths and in between a variable-thickness filler, clamped along its oblique edges and arbitrarily constrained along its parallel edges. The system of six equations in displacements is rewritten in divergence form and solved by a modification of successive approximations, with the aid of approximate recurrence relations for the coefficients. The algorithm has been programmed in FORTRAN for an M-4030 computer. Typical results are shown for one of 12 compressor blades running at the speed of 1500 rpm, containing polyurethane foam as filler between the two St20 steel sheaths. Figures 3, table 1, references 8: Russian.
[247-2415]

UDC 539.3

STRESSED STATE OF ORTHOTROPIC CLOSED CYLINDRICAL SHELL WITH LONGITUDINAL SLITS (CRACKS)

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 17 Sep 79) pp 42-47

OSADCHUK, V. A. and KOSTENKO, I. S., Institute of Application Problems in Mechanics and Mathematics, UkSSR Academy of Sciences, L'vov

[Abstract] Stresses in an orthotropic closed cylindrical shell with a periodic array of longitudinal slits (cracks) are analyzed on the basis of the general moment theory. The resolvent equation for an infinitely long circular cylindrical shell with the axes of orthotropy parallel to the lines of principal curvatures is derived by the distortion method and with the aid of the complex Novozhilov transformation. The problem of the perturbed state of stress under an external load with equal but opposite forces and moments acting at opposite edges of each slit reduces to a system of singular integral equations. Their solution, according to the algorithm of mechanical quadratures, yields the dependence of the stress intensity coefficients on the number of slits and on the parameter

$\lambda = \frac{E_2}{4G} + \frac{G(1-\nu_1\nu_2)}{E_1}$ (E- Young modulus, ν- Poisson ratio, G- shear modulus, 1- longitudinal, 2- transverse). Both stress intensity coefficients vary nonmonotonically with the number of slits, each becoming minimum at some number of the latter. Figures 2, references 7: 5 Russian, 2 Western.
[247-2415]

UDC 539.3:629.7

STABILITY OF ORTHOTROPIC CYLINDRICAL SHELL WITH FILLER LOADED SIMULTANEOUSLY BY AXIAL COMPRESSION AND LATERAL BODY FORCES

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 26 Jun 79) pp 35-41

BOGDANOVICH, A. Ye., Institute of Polymer Mechanics, LaSSR Academy of Sciences, Riga

[Abstract] The static stability of an orthotropic circular cylindrical shell with an isotropic elastic material filling the inside cavity is considered when axial compression and lateral body forces act simultaneously on such a shell. The analysis is based on the equations of equilibrium in the subcritical state, with appropriate boundary conditions at both bases. Displacements, reaction of the filler, and the critical axial force are calculated accordingly. Typical numerical data are shown. The results reveal that the critical axial load depends less on the lateral body forces as the density of the filler material decreases, but the modulus of elasticity of this material plays an insignificant role here. The effect of lateral body forces depends strongly on the time at which they appear anddon the inside radius of the filler. Figures 2, tables 2, references 5: 4 Russian, 1 Western.
[247-2415]

UDC 539.3:534.1

SOUND RADIATION FROM PARTIALLY SHIELDED PIEZOCERAMIC SHELLS

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 25 Feb 80) pp 15-21

GRINCHENKO, V. T. and SENCHENKO, I. V., Scientific Research Institute of Structural Engineering, Kiev

[Abstract] Vibrations of an elastic piezoceramic shell in an acoustic medium are analyzed and the effect of their interaction with the radiation load on the acoustic field is evaluated for the simplest case of an infinitely long cylindrical shell with electric polarization across its thickness. Calculations are based on the hypothesis of nondeformable normal and median surfaces. The equations of state describing the relations between mechanical stresses and strains and the electric field components are solved in accordance with the theory of thin shells, assuming that electrodes cover the entire lateral surface. The resulting system of algebraic equations describes coupled elastic vibrations of a partially (laterally) shielded shell in a fluid. These equations, appearing in the form of infinite series, are solved by the reduction method, with the number of terms retained depending on the specific case. Figures 4, references 5: 4 Russian, 1 Western.
[247-2415]

UDC 539.63

OPTIMIZATION OF DYNAMIC EFFECTS IN SHELLS OF REVOLUTION DURING AXISYMMETRIC MECHANICAL LOADING

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 8 Oct 80) pp 7-14

BURAK, Ya. I. and DOMANSKIY, P. P., Institute of Application Problems in Mechanics and Mathematics, UkSSR Academy of Sciences, L'vov

[Abstract] An isotropic thin uniform-thickness shell of revolution is considered under a transient axisymmetric mechanical load with controllable loading mode and force distribution. The problem of optimizing the deformation so as to avoid loss of dynamic stability is formulated mathematically, with the kinetic-energy functional defined as a volume-time integral of the velocity-squared field serving as optimality criterion. The components of the displacement vector are determined in accordance with the Kirchhoff-Love hypothesis, whereupon relations are established between the displacement functions and the load functions. The differential equations of motion describing these relations are then solved for conditions of the isoperimetric problem. With proper substitution of variables and inclusion of Lagrange multipliers, the kinetic-energy functional is now extremized. The procedure is applied to the specific case of a circular cylindrical shell of given dimensions under an axisymmetric normal impact load striking at time $\tau = 0$. Also acting on the shell are axial forces uniformly distributed over the edges and bending moments which remain constant after time $\tau = 0$. Assuming the shell to be hinge-supported, the surface distribution of the impact force and the intensity of the bending moments are now determined which will minimize the kinetic-energy functional. Typical numerical data are shown for steel shells with the thickness-to-radius ratio $h/R = 1/40$ and the length-to-radius ratio L/R varying from 1 to 6 as well as for steel shells with the length-to-radius ratio $L/R = 2$ and the thickness-to-radius ratio $h/R = 1/40, 1/80, 1/120$. Figures 2, references 5: Russian.
[247-2415]

UDC 539.3

NUMERICAL ANALYSIS OF STRESSED STATE OF ANISOTROPIC MULTILAYER SHELLS ON BASIS OF HYBRID FINITE-ELEMENTS MODEL

Kiev PRIKLADNAYA MEKHANIKA in Russian Vol 18, No 2, Feb 82
(manuscript received 16 Jan 81) pp 3-6

GRIGORENKO, Ya. M. and KOKOSHIN, S. S., Institute of Mechanics, UkSSR Academy of Sciences, Kiev

[Abstract] Shells are considered which consist of an odd number of anisotropic homogeneous layers, all having the same thickness and

physico-mechanical properties and stacked symmetrically with respect to the coordinate surface in accordance with the Kirchhoff-Love hypothesis. The state of stress and strain is determined according to the hybrid finite-elements model, with the corresponding potential-energy functional derived from the principle of its steadiness for anisotropic multilayer shells and under two additional constraints on displacements. With the aid of the Stokes theorem, this functional is transformed to the Reissner functional serving as a basis for computer-aided numerical evaluation of the stress-tensor components. The calculations have been programmed in ALGOL-60 and FORTRAN-4 for a BESM-6 computer. The procedure was used for calculating the stress distribution under uniform pressure in a conical sandwich shell with an orthotropic center layer between isotropic inner and outer ones, rigidly clamped at both bases and having four notches parallel to the axis around the smaller base circle. Figures 3, references 6: 5 Russian, 1 Western.
[247-2415]

UDC 539.3:534.1

STABILITY OF CYLINDRICAL SHELL UNDER PURE BENDING

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 82 (manuscript received 5 Feb 80) pp 187-191

LOKOSHCHENKO, A. M. and SHESTERIKOV, S. A., Moscow

[Abstract] A new approximate method is proposed for solving the problem of instability with loss of load capacity for cylindrical shells made of linearly elastic or other materials. The shell is idealized as a double-layer one. The equations of forces and moments are derived specifically for a shell segment between two cross sections which, after deformation in pure bending, form a dihedral angle with two distinct regions on both sides. These equations are supplemented with static conditions and geometrical constraints as well as physical relations characterizing the shell material. The state of stress and strain in pure bending is determined on this basis, first for a shell made of imcompressible linearly elastic material (which obeys Hooke's law) and then for one made of nonlinearly elastic material with a power-law strain-stress relation ($\varepsilon = B\sigma^n$). The method is also applied to a shell made of a material with steady creep. The accuracy of this method can be estimated on the basis of comparison with results obtained for linearly elastic shells by conventional methods. Figures 5, references 6: 3 Russian, 3 Western.
[242-2415]

UDC 539.3:534.1

COLLAPSE OF CYLINDRICAL STEEL SHELLS UNDER IMPULSE LOAD

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA
in Russian No 2, Mar-Apr 82 (manuscript received 2 Apr 79) pp 183-187

IVANOV, A. G., MINEYEV, V. N. and TYUN'KIN, Ye. S., Moscow

[Abstract] An experimental study was made pertaining to axisymmetric collapse of cylindrical steel shells under impulse loads. Modes of buckling and collapse after loss of stability were determined, for the purpose of establishing their dependence on the magnitude of the impulse and on the active area of its application as well as on the size of geometrically similar shell specimens. The latter were extruded steel pipes, one batch 108 mm dia. x 4 mm thick x 360 mm long and one batch 325 mm dia. x 12 mm thick x 1080 mm long. The width of the explosive charge was varied from 10 to 540 mm, the thickness of the damper cloth was 1.6 mm (single layer) for the smaller pipes and 4.8 mm (triple layer) for the larger pipes. The results, tabulation of data and photographs of collapse patterns, are interpreted according to the theory of dynamic buckling for the small-strain case ($\varepsilon \leq 10\%$) and the large-strain case ($\varepsilon > 10\%$). Increasing the width of the charge was found to cause larger strains in the smaller pipes and a higher degree of fracture in the larger ones, with the scale effect with respect to energy playing a definite role here. Figures 3, table 1, references 18: 10 Russian, 8 Western.
[242-2415]

UDC 533.6.013.42

LOW-FREQUENCY VIBRATIONS OF SHELL OF REVOLUTION IMMERSED IN FLUID

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 2, Mar-Apr 82 (manuscript received 10 Jan 80) pp 155-161

GOLOVANOV, V. A., Moscow

[Abstract] Steady harmonic vibrations of an elastic closed convex shell of revolution are analyzed for the case of such a shell immersed in an infinite volume of an ideally compressible fluid. The latter is characterized by its density, Young modulus and Poisson ratio. The shell surface is referred to a geographic coordinate system and its vibrations are analyzed on the basis of the zero-moment theory for small perturbations with kinematic condition of contact between shell and fluid, and with Sommerfeld conditions at infinity. The shell is assumed to be homogeneous and isotropic, to have a uniform thickness and a smooth median surface, its boundary with the fluid medium being a Lyapunov surface. The corresponding boundary-value problem reduces to the Helmholtz equation, to which are added an appropriate integral equation for the potential and a linear relation for the dynamic

component of pressure. A solution is obtained, after separation of variables (displacement components) and elimination of one, by approximation of first and second derivatives with central difference ratios, piecewise-uniform approximation of the integral equation, and numerical evaluation of the resulting vector equations in sought grid functions. For illustration, results are shown pertaining to an ellipsoidal shell with a 0.005 ratio of thickness to equatorial radius and a 0.75 ratio of equatorial radius (semiminor axis) to polar radius (semimajor axis). Figures 3, references 6: 5 Russian, 1 Western.
[242-2415]

UDC 539.3:534.1

NONAXISYMMETRIC BUCKLING OF CYLINDRICAL SHELLS UNDER DYNAMIC AXIAL COMPRESSION

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian No 2, Mar-Apr 82 (manuscript received 20 Nov 79) pp 144-154

BOGDANOVICH, A. Ye. and FELDMANE, E. G., Riga

[Abstract] A freely supported orthotropic closed circular cylindrical shell is considered under a uniformly distributed axisymmetric axial compression load acting from both ends and varying in time. Deformation of this shell during the nonaxisymmetric buckling stage is described by a system of two Donnell fourth-order nonlinear partial differential equations for the mean deflection and the stress function. The deflection in this case can be expressed in the form of the double infinite sum

$$w(x,y,t) = \sum_{m=1}^{\infty}\sum_{n=0}^{\infty} W_{mn}(t)\sin\alpha_m x.\cos\beta_n y$$ (x- longitudinal coordinate,

y- circumferential coordinate, t- time, W_{mn}- deflection amplitudes, $\alpha_i = \pi m_i/L$, $\beta_i = n_i/R$, L- shell length, R- shell radius, h- shell thickness, m,n- natural numbers). Practicable solution of these equations requires determining the minimum number of terms, and hence the number of nonlinear ordinary differential equations necessary for sufficiently accurate description of nonlinear buckling. The Bubnov-Galerkin method for a binomial approximation is extended to approximation with the single finite sum

$$w(x,y,t) = \sin\alpha_m x\sum_{n=n_0}^{N} W_{mn}(t)\cos\beta_n y$$ (m- fixed number, n_0,N- arbitrary natural

numbers). The shape of the deformed shell surface is then determined, taking into account the initial deflection (imperfection) $w_0(x,y)$. The state of stress is analyzed on the basis of Kirchhoff-Love hypotheses. The critical load and the dynamicity factor are calculated numerically, on the basis of the Mises yield criterion, for various ratios L/R and R/h as well as various impact velocities ranging from 0.25 to 2.0 Mach. Figures 11, references 15: 12 Russian, 3 Western.
[242-2415]

UDC 539.3:534.1

IMPACT OF VISCOELASTIC BODY AGAINST SHALLOW SPHERICAL SHELL

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 2, Mar-Apr 82 (manuscript received 3 Apr 80) pp 138-143

SENITSKIY, Yu. E., Kuybyshev

[Abstract] Deformation and vibration of a thin shallow elastic shell under concentrated straight radial impact by a viscoelastic body of large mass are determined on the basis of the Maxwell-body model and geometrical relations. The integral equation of contact pressure, as function of time, is first linearized and solved with the aid of Laplace transformation. Numerical data on strains, shell reaction and vibration frequencies have been obtained for impact by a mass of 10^4 kg at a velocity of 1 m/s against a 1.15 m thick spherical segment (radius of sphere 35.5 m, radius of base circle 23.1 m) rigidly clamped around the base contour and made of a material characterized by density $\rho = 2.4 \cdot 10^3$ kg/m^3, modulus of elasticity $E = 2 \cdot 10^{11}$ N/m^2, Poisson ratio $\nu = 0.25$, with various values of the Maxwell-body parameters (spring stiffness and viscosity coefficient). The results are comparable with those pertaining to impact against a rigid wall. Local elastic strains are found to appreciably lower the contact pressure but almost not at all the magnitude of the impulse, except in the case of very thin shells. Figures 4, references 9: 8 Russian, 1 Western.
[242-2415]

UDC 539.3:534.1

PROPERTIES OF NATURAL VIBRATION SPECTRA OF SHALLOW SANDWICH SHELLS

Moscow IZVESTIYA AKADEMII NAUK SSSR: MEKHANIKA TVERDOGO TELA in Russian
No 2, Mar-Apr 82 (manuscript received 20 Jul 79) pp 130-137

KHROMATOV, V. Ye., Moscow

[Abstract] Natural vibrations of a shallow elastic sandwich shell or panel consisting of two isotropic carrier layers with a transversely isotropic filler layer in between are analyzed in an orthogonal curvilinear system of coordinates whose axes coincide with the principal lines of shell curvature. The dependence of the spectral density of frequencies on the compliance of the filler in shear and the effect of a zero-moment state of stress on that frequency density have both been evaluated on the basis of physical and computer-aided numerical experiments for shells with positive and negative Gaussian curvatures respectively, loaded in tension or in compression. Asymptotic estimates are obtained for each case, considering the shell or panel to be hinge-supported at the edges. Figures 6, references 11: 8 Russian, 3 Western.
[242-2415]

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